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FEATURES AND MECHANISMS OF THE CORROSION OF STEELS WITH BOILING--ETC(U)

DEC 79 A M SUKHOTIN, N Y LANTRATOVA

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FEATURES AND MECHANISMS OF THE CORROSION OF STEELS WITH BOILING AND CONDENSATION OF N_2O_4

by

A. M. Sukhotin, N. Ya. Lantratova, et al.

FOREIGN TECHNOLOGY DIVISION

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А а	*А а*	A, a	Р р	*Р р*	R, r
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К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

1907

FEATURES AND MECHANISMS OF THE CORROSION OF STEELS WITH BOILING AND CONDENSATION OF N_2O_4

A. M. Sukhotin, N. Ya. Lantratova, S. A. Laterner, V. A. Matushkin, R. Ye. Polyakova, and G. A. Sergeyeva

As already noted [1-5] a large number of stainless steels have high corrosion resistance in N_2O_4 coolant in the range of temperatures 350-700°C, under both static and flow conditions. The surfaces of these materials are, upon contact with nitric oxides, coated with dense oxide films, and a slight increase in weight is observed.

At 100°C under static conditions corrosion of stainless steels occurs with a weight loss, from 0.003 to 0.0005 $g/m^2 \cdot h$.

However, under flow conditions in the boiling and condensation region there is observed a 10-fold increase in the rate of corrosion of stainless steels. Table 1 gives the results of tests with

specimens of steels for corrosion in the boiling and condensation region.

As seen in Table 1, the corrosion of steel Kh18N10T in the region of boiling occurs with a weight loss that varies within the limits -(0.03-0.045) g/m²•h. In the condensation region the values of the corrosion rate are lower, -(0.005-0.02) g/m²•h.

Figure 1 shows the corrosion rate of steels Kh18N10T and EI847 vs temperature distribution over the installation.

The tests were conducted on an installation for studying the corrosion stability of materials in a flow of nitrogen tetroxide, to some extent simulating the operation of an AES [nuclear power plant] circuit.

The temperature distribution over the installation corresponds approximately to that of the working circuit of an AES.

Along the ordinate in Fig. 1 is plotted the corrosion rate, g/m²•h, and along the abscissa - the temperature with functioning of the installation. As can be seen from the figure, maximum corrosion occurs in the boiling zone; in this temperature region (100-130°C) a weight loss is observed, whereas with an increase in the temperature

to approximately 200°C the weight loss is replaced by a significant increase in weight.

In the 350-500°C temperature range the rate of corrosion of stainless steels is insignificant, and increases anew only in the condensation region. In the boiling zone there is observed a significant difference in corroseion stability of steels Kh18N10T and EI847.

The corrosion rate of steel Kh18N10T is 0.045 $g/m^2 \cdot h$, while that of steel EI847 is (0.4-0.6) $g/m^2 \cdot h$, which is greater by at least a factor of 10. In the condensation region this difference is less, while in the high-temperature region the corrosion rates of both steels are approximately the same.

The assumption was made that the reason for the increased corrosion rate in the boiling and condensation region is the local increase in nitric-acid content. Since nitric acid is the least volatile component of the mixture, in the boiling and condensation region its content in the liquid phase can be noticeably higher that in the initial nitrogen tetroxide.

To check the validity of this assumption we conducted a series of experiments on the study of the corrosion of materials under

static conditions in nitrogen tetroxide containing varying quantities of water or HNO_3 at 130-170°C and a pressure of 40-80 atm.

As can be seen from Table 2, with an increase in water content in N_2O_4 the corrosion rate of steel Kh18N10T at 150°C increases, whereas at 20 and 50°C the addition of such quantities of water led to a significant decrease in the corrosion rate. This confirms the correctness of our assumption.

Since the absolute values of the corrosion rate of steel Kh18N10T in N_2O_4 containing 0.7% H_2O are close to the corrosion rate of this steel in the boiling region under flow conditions, it was possible to consider that to some extent we were able, under static conditions, to reproduce the conditions occurring in the working circuit during boiling.

Figure 2 gives the comparative characteristics of the corrosion resistance of various brands of steels under static conditions at 150°C, 50 atm(tech) in N_2O_4 containing 0.7 wt.% H_2O. Similar data are given in Fig. 3 for the boiling region under N_2O_4 flow conditions.

As can be seen, steels EI654 and EI696M containing up to 3% Ti have somewhat better corrosion resistance as compared with steel

Kh18N10T.

Steel EI612 containing more Ni has lower resistance. Steels containing Mo, Ni, and Mn have even lower resistance.

Thus, under conditions of boiling and condensation, unlike in the high-temperature region, the corrosion resistance of steel is a function of its composition. Even small quantities of elements unstable in N_2O_4 significantly lower the corrosion resistance of materials.

Increased corrosion of stainless steels can also be observed in those parts of the installation where there is possible, as a result of periodic shutdowns, condensation of the coolant and its subsequent evaporation during heating. When conducting corrosion tests under static conditions we observed increased corrosion in the narrow gap of the upper part of the thermocouple recess and in the lower feed pipe. The rate of corrosion reached from 1 to 3.5 mm/year.

The temperature region of 180-350°C is interesting. Under static conditions at 350°C a slight weight gain is observed. Under coolant flow conditions, however, this weight gain reaches a significant magnitude. The surfaces of the specimens are coated with dark, dense, sometimes slightly rough, films. After removal of the films the

change in weight of the specimens was insignificant. The corrosion rate in this region, calculated from the weight loss, is shown in Fig. 1, curve 2.

Thus the weight gain in this case is caused primarily by deposition, on the surfaces of the steel, of corrosion products entrained by the flow of coolant from the boiling region. Such a picture is observed only for this temperature region.

We observed an analogous picture on one of the sections of the testing unit. When studying the corrosion resistance of materials in a flow, we cut from the stand a section of pipe which was critically analyzed at 300-350°C for 4000 h and subjected to jet impact.

When studying the microstructure we found that on the wall of the pipe subjected to jet impact there was a thick film whose thickness gradually decreased. In addition, there was erosion destruction of the metal. The opposite wall of the pipe remained visibly unchanged.

To trace the distribution of the deposits, small glass tubes were placed together with metal specimens in various parts of the installation for corrosion testing in N_2O_4 flow. On these tubes in the temperature range of 50-130°C we observed a slight oily deposit;

in the temperature region of 200-300°C, however, a thick dark film formed. The glass tubes in the 400-500°C region remained clean.

Studies conducted by us previously showed that complex salts form during the corrosion of stainless steel in liquid N_2O_4. These salts, getting into the high-temperature region and being thermally unstable, are converted into oxides which apparently are deposited on the metal in the form of comparatively dense thick films.

This process can be facilitated by the fact that one of the basic products of the corrosion of steels, viz., nitrosonium tetranitroferrate, is volatile.

Leningrad Institute of Applied Chemistry

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Table 1. Corrosion resistance of structural materials under conditions of N_2O_4 coolant flow (V = 10-30 m/s; P = 20-25 atm(tech); τ = 360 h).

1 Температура, С	2 Скорость коррозии, $г/м^2 \cdot час$		3 Примечание
	4 Х18Н10Т	5 ЭИ847	
30—40	−0,001	−0,002	
100	−0,045	−0,420	кипение 6
250—300	+0,017	+0,011	
550	0,006	−0,001	
100	−0,020	−0,045	конденсация 7
130—150	−0,040	−0,60	кипение 6
190—220	0,040	−0,036	
300—340	0,030	0,020	
500—510	0,001	0,001	
180—200	−0,005	—	
45	−0,001	—	
105	−0,031	−0,410	кипение 6
245	0,021	0,028	
120—160	0,001	−0,008	
100	−0,006	−0,017	конденсация 7

Key: 1 - Temperature, °C; 2 - Corrosion rate, $g/m^2 \cdot h$; 3 - Remarks; 4 - Kh18N10T; 5 - EI847; 6 - boiling; 7 - condensation.

Table 2. Corrosion rate of steel Kh18N10T vs H_2O and HNO_3 content in N_2O_4 (τ = 360 h).

1 Содержание примесей в N_2O_4, вес. %		2 Температура, °C	3 Давление, *ат*	4 Скорость коррозии, *г/м²·час*	
H_2O	HNO_3			5 жидкая фаза	6 газовая фаза
Исходная 7	N_2O_4	145—160	86—40	0,002—0,009	0,001—0,013
0,11—0,15		135—155	78—32	0,005—0,008	0,008—0,017
0,32		145—150	76—52	0,038	0,009
0,66—0,7		130—170	77—38	0,022—0,099	0,010—0,068
	5,28	150—155	65—52	0,260	0,127

Key: 1 - Content of impurities in N_2O_4, wt.%; 2 - Temperature, °C; 3 - Pressure, atm(tech); 4 - Corrosion rate, g/m²•h; 5 - liquid phase; 6 - gaseous phase; 7 - Starting.

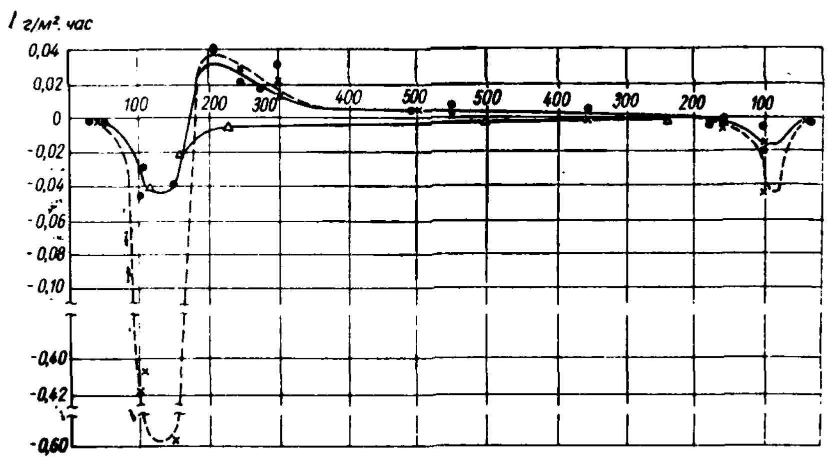

Fig. 1. Corrosion rate of steels Kh18N10T and EI847 in various temperature regions of the installation: solid lines - Kh18N10T; dashed lines - EI847.

Key: 1 - g/m²•h.

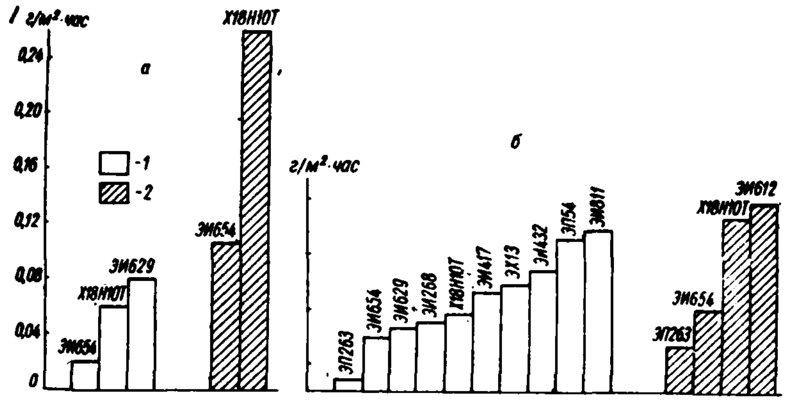

Fig. 2. Corrosion rate of structural materials in N_2O_4 with additions of H_2O or HNO_3 under static conditions ($t = 150 \pm 10°C$, $\tau = 360$ h): a - liquid phase, b - gaseous phase; 1 - N_2O_4 + 0.7 wt.$^0/_0$ H_2O; 2 - N_2O_4 + $5^0/_0$ HNO_3.

Key: 1 - $g/m^2 \cdot h$.

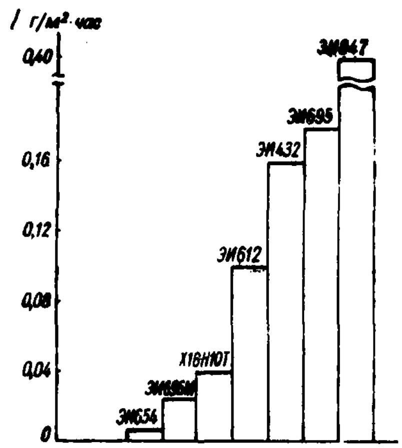

Fig. 3. Corrosion resistance of structural materials in flow of N_2O_4 in the boiling region (V = 10-30 m/s, P = 20-25 atm(tech), τ = 360

h).

Key: 1 - $g/m^2 \cdot h$.

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